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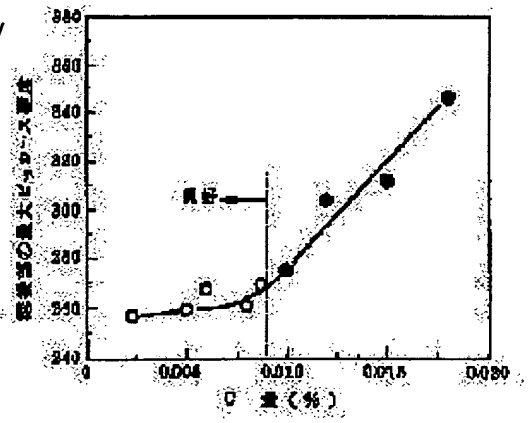
(54) MARTENSITIC STAINLESS STEEL EXCELLENT IN CORROSION RESISTANCE IN WELD ZONE

(57)Abstract:

PURPOSE: To prevent the increase in hardness in a weld zone and to provide corrosion resistance to hydrogen sulfide, carbon dioxide gas, and chlorine ion by incorporating specific amounts of C, Si, Mn, P, S, Cr, Mo, Ni, Al, N, and Fe.

CONSTITUTION: This steel is a martensitic stainless steel which has a composition consisting of ≤0.009% C, ≤1% Si, ≤1% Mn, ≤0.04% P, ≤0.005% S, 9-15% Cr, 1.5-7% Mo, 4-8% Ni, 0.001-0.1% Al, ≤0.1% N, and the balance essentially Fe and satisfying Cr+Mo≥11 and 30C+Ni-1.1Cr-1.1Mo≥-10.5. Because C content is extremely reduced, this steel is free from increases in hardness even if subjected to the influence of high heat at the time of welding, and adequate strength, toughness, and corrosion resistance can be obtained.



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CLAIMS

[Claim(s)]
[Claim 1] Less than [Si:1.0%], less than [Mn:1.0%], P:0.04% or less, S:0.005% or less, Cr:9.0-15.0%, Mo:1.5-7.0%, nickel:4.0-8.0%, aluminum:0.001-0.1%, and N:0.1% or less are contained C:0.009% or less, and it is Cr(%)+Mo(%) >=11.0 (%).
30C(%)+nickel(%)-1.1Cr(%)-1.1Mo(%) >=-10.5 (%)
Martensitic stainless steel excellent in the corrosion resistance of the weld zone characterized by having the steel presentation which it fills to coincidence and the remainder becomes from Fe and an unescapable impurity.
[Claim 2] C:0.009% or less, less than [Si:1.0%], less than [Mn:1.0%], P:0.04% or less, S:0.005% or less, Cr:9.0-15.0%, Mo: -- 1.5 - 7.0%, nickel:4.0-8.0%, aluminum:0.001-0.1%, and

N:0.1% or less -- further -- one sort in less than [Ti:0.2%], less than [Nb:0.2%], and less than [Zr:0.2%], or two sorts or more -- containing -- Cr(%)+Mo(%) >=11.0 [and] (%)
30C(%)+nickel(%)-1.1Cr(%)-1.1Mo(%) >=-10.5 (%)
C -- (-- % --) - 12 -- {-- Ti -- (-- % --) -- /-- 48 -- + -- Zr -- (-- % --) -- /-- 91 -- + -- Nb -- (-- % --) -- /-- 93 - N -- (-- % --) -- /-- 14 --} -- <= -- zero (%) --
Martensitic stainless steel excellent in the corrosion resistance of the weld zone characterized by having the steel presentation which it fills to coincidence and the remainder becomes from Fe and an unescapable impurity.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the martensitic stainless steel suitable for the use as the crude oil which contains corrosive impurities, such as carbon dioxide gas, a hydrogen sulfide, and a chlorine ion, especially, or a line pipe of natural gas about the martensitic stainless steel excellent in the corrosion resistance of a weld zone about the martensitic stainless steel for line pipes used for transportation of the crude oil or natural gas extracted mainly from the oil field and the gas field.
[0002]
[Description of the Prior Art] In recent years, development of an oil well and a gas well carries out exhaustion-ization of the petroleum resources expected at a jump and the near future of a crude price at hand, and a depths oil field upon which it did not look back, and 1 ** are performed conventionally briskly [the sour gas rice field where development was abandoned] on a scale of worldwide. Generally, depth is very deep and, as for such an oil well and a gas

well, the quality of the material with which the crude oil or natural gas containing carbon dioxide gas, a hydrogen sulfide, and a chlorine ion was increasing and which it moreover combines with corrosion resistance and stress-corrosion-cracking-proof nature with high intensity also to a crude oil or the line pipe for natural gas transportation along with it is required.

[0003] Although it was common to have used carbon steel or low alloy steel as for the conventional line pipe, the steel to which the alloy element was made to increase is increasingly used as the environment to be used becomes cruel. For example, SUS which added Cr currently widely used as steel pipes for oil well use 13% in the environment containing many carbon dioxide gas since addition of Cr raised corrosion resistance remarkably Although there is also an example which used 420 martensitic stainless steel for line pipes SUS In order that a weld zone may harden 420 martensitic stainless steel remarkably by the girth weld, the actual condition is that heat treatment after welding is needed and the use is restricted poor [sulfide-proof stress-corrosion-cracking nature] remarkably [the rise of cost]. Although the duplex stainless steel and super duplex stainless steel which raised the alloy element further in the present condition to the bottom of the environment which contains such carbon dioxide gas and a hydrogen sulfide in coincidence must be used, since addition of an alloy element increases, the rise of cost is remarkable.

[0004] moreover, as the quality of the material which moreover combines corrosion resistance and stress-corrosion-cracking-proof nature with high intensity C:0.02% or less, less than [Si:0.50%], Mn:0.50-1.50%, S:0.005% or less, Cr:12-15%, nickel:3.5-6%; Mo: The martensitic stainless steel with which 0.5-3% is contained and the remainder consists of Fe and an unescapable impurity (JP,60-174859,A), C:0.05% or less, less than [Si:1.0%], Mn:0.1-3.0%, P:0.04% or less, S:0.005% or less, Cr:15-19%, nickel: 3.5-8.0%, aluminum:0.001-0.1%, N:0.1% or less, Mo: The martensitic stainless steel with which the remainder consists of Fe and an unescapable impurity 0.1-4.0% (JP,2-243739,A), C:0.05% or less, less than [Si:1.0%], Mn:0.5-3.0%, P:0.04% or less, S:0.005% or less, Cr:9.0-15%, Mo: 0.1-7.0%, nickel:2-8%, aluminum:0.001-0.1%, Further N:0.1% or less Less than [Ti:0.5%], less than [Nb:0.5%], One sort in V:0.5% or less and less than [Zr:0.5%] or two sorts or more, and the remainder consist of Fe and an unescapable impurity, and are 30Cr(%)+36Mo(%)+14Si(%)-28nickel(%) <=455 (%).

21Cr(%)+25Mo(%)+17Si(%)+35nickel(%) <=731 (%)

The martensitic stainless steel which comes out and has a certain steel presentation (JP,2-243740,A), C:0.05% or less, less than [Si:1.0%], less than [Mn:0.5%], P:0.04% or less, S:0.002% or less, Cr:8-15%, Mo:1.5-7%, nickel:2-8%, aluminum:0.001-0.1%, N:0.1% or less, and Cr+Mo>=11.0(%)30Cr(%)+36Mo(%)+14Si(%)-28nickel(%) <=455 (%)

21Cr(%)+25Mo(%)+17Si(%)+35nickel(%) <=731 (%)

The martensitic stainless steel which has the steel presentation which it is satisfied with coincidence and the remainder becomes from Fe and an unescapable impurity (JP,3-120337,A), C:0.05% -- super- -- 0.2% or less, less than [Si:2%], and Mn: -- 2% or less P:0.04% or less, S:0.01% or less, less than [more than Cr:8%17%], nickel:2.5 -- super- -- 8% or less, less than [more than aluminum:0.001%0.1%], N:0.1% or less, however 30Cr(%)+14Si(%)-28nickel(%)-790[C(%)+N(%)] <=455 (%)
21Cr(%)+17Si(%)+35nickel(%)+910[C(%)+N(%)] <=731 (%)
Many proposals, such as martensitic stainless steel (JP,4-120249,A) which has the steel presentation which consists of the remainder Fe and an unescapable impurity, are performed.
[0005]
[Problem(s) to be Solved by the Invention] Although surely corrosion resistance of martensitic stainless steel of the indication to said JP,60-174859,A improves a little by addition of Cr and Mo under the environment only containing carbon dioxide gas, if it does not have corrosive [sufficient] or is going to use it especially for a line pipe, it cannot have corrosion resistance with it extremely in the corrosive high environment which contains corrosive impurities, such as carbon dioxide gas, a hydrogen sulfide, and a chlorine ion, so much. [the remarkable degree-of-hardness rise of a weld zone, and] [sufficient] Moreover, the martensitic stainless steel of the indication to JP,2-243739,A, JP,2-243740,A, JP,3-120337,A, and JP,4-120249,A can improve extremely corrosive [in the corrosive high environment which contains corrosive impurities, such as carbon dioxide gas a hydrogen sulfide and a chlorine ion, so much], and if it has good corrosion resistance also as [hardening / of about 800-1000 degrees C] as heat treatment, it has become. However, a girth weld is indispensable, and although such martensitic stainless steel will be satisfactory at all if it is used as a Yui tubing application, in order to use it as a line pipe application, since it becomes the elevated temperature which is 1000-1400 degrees C near the weld zone, a degree of hardness rises remarkably and stress corrosion cracking occurs, and if it remains as it is, it has the trouble that it cannot be used for a line pipe.
[0006] The purpose of this invention is in the member which carries out and uses welding construction of a line pipe etc. to offer the martensitic stainless steel which has the stress-corrosion-cracking-proof nature under the corrosive environment which controls the degree-of-hardness rise of a weld zone, and contains the outstanding reinforcement, toughness and a hydrogen sulfide, carbon dioxide gas, and a chlorine ion.
[0007]
[Means for Solving the Problem] So that this invention persons may investigate the effect of the alloy element exerted on the corrosion resistance centering on the stress-corrosion-cracking-proof nature under the environment which contains carbon dioxide gas, a hydrogen sulfide, and a chlorine ion that the above-mentioned purpose should be attained As a result of

repeating various kinds of experiments and examination, with the steel which carried out proper amount addition, nickel In order to increase the amount of effective Cr and Mo from which the corrosion resistance under the above-mentioned environment can arrange in the amount of %s (Cr+Mo), and has become neither carbide nor a nitride In order to prevent that what is necessary is just to specify the upper limit of C and N, and the degree-of-hardness rise of a weld zone In order to obtain that it is absolutely indispensable to reduce the absolute magnitude of C remarkably, and the reinforcement stabilized still more industrially in order to suppress that addition of Ti, Nb, and Zr which see in C and the amount of N and suit them is effective, and the degree-of-hardness rise of a heat affected zone, the knowledge that addition of Ti, Nb, and Zr was effective was acquired. By reducing the amount of C very conventionally more remarkably than level, and carrying out minute amount addition of the carbon nitride stability elements, such as Ti, Nb, and Zr, on it, as a result of repeating research furthermore It studied that even hardening from an elevated temperature (1000-1400 degrees C) like welding heat effect could stabilize reinforcement, carried out it not through hardening of the martensite which was common sense until now, and tempering processing, and suitable reinforcement, toughness, and corrosion resistance were acquired also with hardening, and this invention was reached.

[0008] Namely, this invention contains less than [Si:1.0%], less than [Mn:1.0%], P:0.04% or less, S:0.005% or less, Cr:9.0-15.0%, Mo:1.5-7.0%, nickel:4.0-8.0%, aluminum:0.001-0.1%, and N:0.1% or less C:0.009% or less, and is Cr(%)+Mo(%) >=11.0 (%).

30C(%)+nickel(%)-1.1Cr(%)-1.1Mo(%) >=-10.5 (%)

It is the martensitic stainless steel excellent in the corrosion resistance of the weld zone characterized by having the steel presentation which it fills to coincidence and the remainder becomes from Fe and an unescapable impurity.

[0009] This invention Moreover, C:0.009% or less, less than [Si:1.0%], less than [Mn:1.0%], P:0.04% or less, S:0.005% or less, Cr:9.0-15.0%, Mo: -- 1.5 - 7.0%, nickel:4.0-8.0%, aluminum:0.001-0.1%, and N:0.1% or less -- further -- one sort in less than [Ti:0.2%], less than [Nb:0.2%], and less than [Zr:0.2%], or two sorts or more -- containing -- Cr(%)+Mo(%) >=11.0 [and] (%)

30C(%)+nickel(%)-1.1Cr(%)-1.1Mo(%) >=-10.5 (%)

C -- (-- % --) - 12 -- {-- Ti -- (-- % --) -- /-- 48 -- + -- Zr -- (-- % --) -- /-- 91 -- + -- Nb -- (-- % --) -- /-- 93 - N -- (-- % --) -- /-- 14 --} -- <= -- zero (%) --

It is the martensitic stainless steel for line pipes characterized by having the steel presentation which it fills to coincidence and the remainder becomes from Fe and an unescapable impurity.

[0010]

[Function] The martensitic stainless steel of this invention does not carry out hardening and tempering processing which are the common sense of martensitic stainless steel

conventionally, but its variation on the strength is small, and excellent in reinforcement, toughness, and corrosion resistance also as [rolling] or as [hardening]. Moreover, since the variation on the strength at the time of hardening is small, the control on the strength after tempering processing is also easy for the martensitic stainless steel of this invention. Furthermore, even if the martensitic stainless steel of this invention receives a high thermal effect like welding by being referred to as super-low C, it does not have a degree-of-hardness rise, and it can acquire suitable reinforcement, toughness, and corrosion resistance.

[0011] Moreover, the martensitic stainless steel of this invention does not carry out hardening and tempering processing which are the common sense of martensitic stainless steel conventionally, but its variation on the strength is small, and excellent in reinforcement, toughness, and corrosion resistance also as [rolling] or as [hardening]. Moreover, since the variation on the strength at the time of hardening is small, the control on the strength after tempering processing is also easy for the martensitic stainless steel of this invention. Furthermore, even if the martensitic stainless steel of this invention receives a high thermal effect like welding by being referred to as super-low C, it does not have a degree-of-hardness rise, further, a degree-of-hardness rise is controlled by addition of Ti, Nb, and Zr, and a low-temperature heat affected zone can also acquire more suitable reinforcement, toughness, and corrosion resistance by it.

[0012] Next, the reason which limited the chemical entity of steel in this invention is explained in full detail. C was the important element of this invention, and in order for that heat affected zone to become remarkably hard at the time of the welding construction which becomes indispensable and to degrade toughness and corrosion resistance in case it will be used as a line pipe, if it exceeds 0.009% as shown in drawing 1 , it could be 0.009% or less. Although Si was required of the usual steel-manufacture process as a deoxidizer, since toughness fell when it exceeded 1.0%, it could be 1.0% or less. Since it had the operation which reduces toughness, little direction for the improvement in toughness of Mn was desirable, and although it was the element which raises reinforcement, in order to make reinforcement and toughness both hold on suitable level, it could be 1.0% or less. The more P was low, the more toughness improved, but since toughness would fall remarkably if it exceeds 0.04%, it could be 0.04% or less. Although it was more desirable as there was little S, when carrying out from a viewpoint of hot-working nature, it could be 0.005% or less from balance with desulfurization cost.

[0013] In order to form a corrosion-resistant coat, 9.0% or more of addition was required for Cr, but since it would become easy to generate a ferrite and reinforcement would fall according to the synergistic effect with Mo if it exceeds 15%, it could be 9.0 - 15%. Although Mo had remarkable effectiveness in the corrosion-resistant improvement to a hydrogen sulfide, effectiveness sufficient at less than 1.5% was not acquired, but since it would become easy to generate a ferrite and reinforcement would fall according to the synergistic effect with Cr if it

exceeds 7%, it could be 1.5 - 7.0%. The corrosion resistance improvement effect of a heat affected zone of especially Mo is remarkable, and 2.0% or more of its addition is desirable. nickel was added in order to obtain required reinforcement, corrosion resistance, and hot-working nature, but at less than 4.0%, if the effectiveness falls to about [not being enough] or reverse and exceeds 8.0% on balance with Cr and Mo, in order to cause a cost rise for the effectiveness to not only be saturated, but, it could be 4.0 - 8.0%. Although aluminum was required of the usual steel-manufacture process as a deoxidizer, since the inclusion in steel increases in number and corrosion resistance was degraded when the effectiveness was not acquired at less than 0.001% but it exceeded 0.1%, it could be 0.001 - 0.1%. If N exceeds 0.1%, reinforcement will rise too much, sulfide stress corrosion crack sensitivity will become high, and also from a corrosion resistance field, little direction is desirable and is 0.02% or less desirably.

[0014] Although Ti, Nb, and Zr are the important elements of the 2nd invention of this application, generate C, N, and a compound at the time of hot hot working and solution-izing, and have the operation which controls free C in steel, and the amount of N, and a degree-of-hardness rise can be controlled even if it receives the thermal effect at the time of welding construction Since it generated an element and compounds, such as nickel, conversely and the effectiveness is not only saturated, but became hard when it exceeded 0.2% on the balance of C and N, it could be 0.2% or less. The more many [at 14.0% or more / stress-corrosion-cracking-proof nature does not have enough Cr(%)+Mo (%) it is required of less than 11.0% 11.0% or more and / preferably], the more stress-corrosion-cracking-proof nature improves, but if it adds too much, in order to become easy to generate a ferrite and to cause a cost rise for reinforcement not only to to fall, but, it does not exceed 22.0%.

[0015] Furthermore, the steel presentation in this invention must satisfy the following formula (1) and a formula (2).

30Mo[C(%)+nickel(%)-1.1Cr(%)-1.1] (%) >= -10.5 (%) ..... a formula (1)

C(%)-12 -- {-- Ti (%)/48 -- 93-N [+Zr(%) / 91+Nb(%) /] (%)/14 --} -- <= -- 0 (%) .... Formula (2)

In order to carry out hot forming of the object steel of this invention easily, if it is desirable that it is austenite single phase, it becomes austenite single phase at 900-1250 degrees C which is whenever [usual stoving temperature] and it cools at an elevated temperature, to metamorphose into a martensitic stainless steel is required. In order to carry out hot forming in the state of austenite single phase, without a delta ferrite generating at an elevated temperature, it is necessary to satisfy the above-mentioned formula (1). Moreover, when securing the reinforcement which was excellent since the object steel type of this invention needed welding construction, such as an object for line pipes, toughness, and corrosion resistance As an element which the degree of hardness by which the weld zone was stabilized is [element] required, and the heat affected zone of a weld zone is attained [element] by

being referred to as super-low C, and stabilizes free C further at the time of hot working and solution-izing In order to attain the degree of hardness stabilized by adding Ti, Nb, and Zr, it is indispensable to satisfy the above-mentioned formula (2).

[0016]

[Example] Steel No.1-18 shown in Table 1 were ingoted, and it hot-rolled, respectively, and considered as the plate of 8mm of board thickness. Subsequently, after heat-treating at predetermined temperature, V edge preparation were performed to each plate, all layer TIG arc welding was carried out, and it examined about the yield strength of a weld zone, microhardness, toughness, and sulfide stress-corrosion-cracking nature. A tension test cuts down a test piece for tensile test with 4mm [in thickness], and a die length [of a parallel part] of 34mm from a plate, and is JIS. Yield strength was measured according to the convention of the Z2241 metallic-material tension test approach. A microhardness trial is JIS. It is JIS about the center section of the thick direction of a test piece 1 as shown in drawing 2 using the microhardness tester of B7734. According to the convention of the Z2244 Vickers-hardness-test approach, Vickers hardness number was measured in 0.5mm pitch by 9.807 Ns of test loads, and the maximum estimated. In addition, 2 shows a weld zone and 3 shows point of measurement. Toughness starts the piece of a Charpy test of 2mmV notch whose dimension is 10mmx5mmx55mm, and is JIS. A regular Charpy impact tester is used for B7722, and it is JIS. The Charpy impact value measured according to the Z2242 metallic-material impact test approach estimated. As sulfide stress-corrosion-cracking nature is shown in drawing 3 The thickness of T= 2mm, width of face of W= 10mm, A test piece 11 so that two four-point test pieces for bend test 11 with a die length of L= 75mm may be produced and may be shown subsequently to drawing 4 (a) by the two supporting points (spacing of 60mm) of the top face of the bending fixture 12, and the inferior-surface-of-tongue 2 supporting point (spacing of 10mm) of the bending device 13 Sigma=Ety {2/3L12+L1L2+1 / 4L22} It carried out, where bending stress is attached so that the stress expressed by -1 may be set to 1sigmay (sigmay:0.2% proof stress). In addition, E in a formula shows Young's modulus. The bending configuration of the test piece 11 at this time was as being shown in drawing 3 (b). The test atmosphere was made into 5%NaCl+0.01atmH2S+30atmCO2 and 25 degrees C, and after the test piece was immersed for 366 hours, the existence of a crack was investigated by drawing, the appearance observation by the naked eye, and optical microscope observation. These test results are collectively shown in Table 2. In addition, it breaks that both two there are that both two it is with "OO" in the sulfide stress-corrosion-cracking column in Table 2 with crack nothing and "xx", and it shows generating.

[0017]

[Table 1]

	鋼No.	化学成分(%)														
		C	Si	Mn	P	S	Cr	Ni	Mo	Al	N	Ti	Nb	Zr	☆X	☆Y	☆Z
本発明例	1	0.003	0.48	0.66	0.02	0.001	12.9	6.7	2.2	0.008	0.008	–	–	–	15.1	−9.83	–
	2	0.008	0.55	0.29	0.01	0.001	11.3	4.5	1.8	0.013	0.002	–	–	–	13.0	−9.56	–
	3	0.006	0.23	0.50	0.02	0.001	14.1	7.8	2.4	0.035	0.009	–	–	–	16.5	−10.17	–
	4	0.006	0.45	0.44	0.01	0.001	12.2	6.2	2.1	0.022	0.008	–	–	–	14.3	−9.35	–
	5	0.005	0.20	0.30	0.02	0.001	12.1	6.1	2.6	0.032	0.007	0.09	–	–	14.7	−9.92	−0.012
	6	0.006	0.23	0.31	0.01	0.001	12.2	5.8	2.2	0.022	0.007	–	–	0.12	14.4	−9.86	−0.004
	7	0.009	0.45	0.48	0.02	0.002	11.3	4.9	2.4	0.011	0.004	0.05	0.05	–	13.7	−9.90	−0.007
	8	0.009	0.37	0.24	0.03	0.003	11.0	5.8	2.0	0.025	0.011	–	0.08	0.09	13.0	−8.23	−0.004
	9	0.005	0.58	0.24	0.02	0.002	14.5	7.8	1.6	0.004	0.008	–	0.14	–	16.1	−9.76	−0.006
	10	0.005	0.32	0.58	0.02	0.001	12.5	6.5	2.4	0.022	0.005	0.04	0.05	0.05	14.9	−9.74	−0.014
	11	0.005	0.33	0.64	0.02	0.001	11.9	5.8	1.9	0.024	0.005	0.08	–	–	13.8	−9.23	−0.011
	12	0.004	0.41	0.19	0.02	0.001	10.2	5.2	3.4	0.007	0.004	0.07	–	–	13.6	−9.26	−0.012
比較例	13	0.060*	0.50	0.41	0.02	0.002	16.2*	4.3	–*	0.008	0.009	0.04	0.31	–	16.2	−11.72*	0.018*
	14	0.005	0.24	1.23*	0.02	0.002	13.1	2.1*	1.1*	0.005	0.007	0.06	–	–	14.2	−13.37*	−0.004
	15	0.220*	0.48	0.54	0.02	0.002	9.1	0.1*	1.1*	0.024	0.006	–	–	–	10.2	−4.52	0.225*
	16	0.006	0.45	0.59	0.02	0.002	12.5	5.5	1.7	0.008	0.004	0.25*	–	–	14.2	−9.94	−0.053
	17	0.013*	0.30	0.45	0.02	0.001	11.8	4.1	2.2	0.023	0.005	0.05	0.07	0	14.0	−10.91*	−0.004
	18	0.018*	0.32	0.55	0.01	0.001	12.3	6.1	2.1	0.033	0.005	0.08	0	0	14.4	−9.20	0.002*

*：本発明範囲外
☆X＝Cr(%)＋Mo(%)
☆Y＝30C(%)＋Ni(%)−1.1Cr(%)−1.1Mo(%)
☆Z＝C(%)−12{Ti(%)/48＋Zr(%)/91＋Nb(%)/93−N(%)/14}

[0018]

[Table 2]

	鋼No.	引張強度 (MPa)	最高硬度 (HV1)	衝撃値 (J/cm²)	応力腐食割れ試験結果
本発明例	1	803	262	244	○○
	2	756	265	241	○○
	3	895	283	259	○○
	4	878	278	240	○○
	5	840	265	220	○○
	6	823	260	250	○○
	7	891	280	218	○○
	8	872	274	234	○○
	9	791	247	251	○○
	10	859	270	276	○○
	11	847	264	235	○○
	12	833	259	232	○○
比較例	13	1154	402	24	××
	14	775	261	218	××
	15	1325	451	34	××
	16	942	330	220	××
	17	921	310	264	××
	18	1025	357	241	××

[0019] In comparison steel of steel No.13-18 other than the presentation range of this invention, each has produced stress corrosion cracking under the environment of hydrogen-sulfide 0.01atm as shown in Table 1 and 2. It sheep-adds, or steel No.13 of comparison steel, and 14 and 15 run short of Mo contents, and stress corrosion cracking is produced. moreover, steel No. of comparison steel -- although 17 and 18 are the level currently conventionally called low [Ç], considering the degree-of-hardness rise under welding heat effect, its C content is still high and stress corrosion cracking has generated them. Since steel No.16 of comparison steel have too many additions of Ti, Nb, and Zr, the compound with nickel etc. generated and hardened them and stress corrosion cracking has generated them. On the other hand, the degree-of-hardness rise of a weld zone is controlled, stress-corrosion-cracking-proof nature is improved, and stress corrosion cracking does not occur, but, moreover, each steel No.1-12 of this invention steel is excellent in reinforcement and toughness.

[0020]

[Effect of the Invention] In case it is used as a line pipe etc., the martensitic stainless steel of this invention can prevent the degree-of-hardness rise by the thermal effect of the weld zone which becomes indispensable, and possesses the corrosion resistance can be satisfied with the bottom of the cruel environment containing a hydrogen sulfide, carbon dioxide gas, and a chlorine ion of corrosion resistance, and reinforcement and toughness are excellent, as stated above, and it can fully be used as a martensitic-stainless-steel member used welding.

[Translation done.]

DESCRIPTION OF DRAWINGS

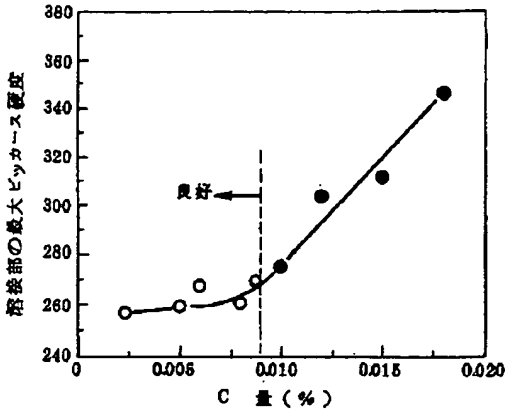
[Brief Description of the Drawings]

[Drawing 1] It is the graph which shows the generating situation of the maximum degree of hardness of the weld zone at the time of changing C content in martensitic stainless steel, and stress corrosion cracking.
[Drawing 2] It is the explanatory view showing the degree-of-hardness measuring point of the weld zone used in the example.
[Drawing 3] It is the perspective view showing the configuration of the four-point test piece for bend test used in the example.
[Drawing 4] The state diagram and the (b) Fig. where the stress addition condition of the test piece using a bending fixture is shown, and the (a) Fig. set the test piece to the bending fixture are an explanatory view of the test piece of a stress addition condition.
[Description of Notations]
1 11 Test piece
2 Weld Zone
3 Point of Measurement
12 Bending Fixture
13 Bending Device

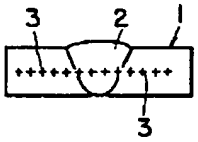
[Translation done.]

DRAWINGS

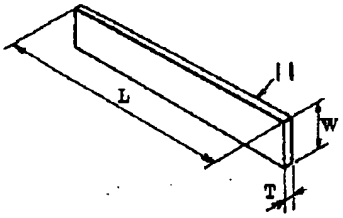
[Drawing 1]



[Drawing 2]

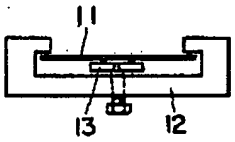


[Drawing 3]

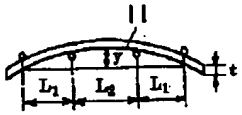


[Drawing 4]

(a)



(b)



[Translation done.]